FILE

OZONE SYMPTOMS WERE PRESENT ON BIOINDICATOR PLANTS AT THE OTTER CREEK WILDERNESS AND DOLLY SODS WILDERNESS, MONONGAHELA NATIONAL FOREST, 1989

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ABSTRACT

Ozone appears to be causing damage to vegetation at Dolly Sods and Otter Creek Wilderness. Symptoms were seen on eight bioindicator plants at Otter Creek and/or Dolly Sods Wilderness in late August and early September. The bioindicators with ozone symptoms present had an average severity rating of trace to moderate, but many plants had moderate and heavy ozone symptoms.

The recommendations are: 1) repeat the biological evaluation annually, 2) plant several species of bioindicators, with known ozone sensitivity, within the Wildernesses, and 3) install ozone meters and place filter chambers over seedlings taken from the Wildernesses in order to obtain the most reliable data to support resource managers decisions.

INTRODUCTION

The Dolly Sods Wilderness (10,215 acres) and Otter Creek Wilderness (20,000 acres) are located within the Monongahela National Forest. Both Wildernesses are designated as Class I air quality under the Clean Air Act Amendments of 1977. This legislation is intended to safeguard the air quality of Wildernesses and National Parks by maintaining a level of air pollution at or below the 1977 level. An increase in air pollution from new emission sources could have a negative impact on resource values. Perhaps the most significant air pollution problem in the eastern United States is ozone.

Minimal amounts of ozone may enter the lower atmosphere via natural phenomena, such as: a thunderstorm's electrical discharge, or a hurricane's upper atmospheric disturbance (Lacasse and Treshow, 1978). However, most of the pollutants responsible for the formation of ozone are generated in urban-industrial areas and are carried to remote areas. Fairly high ozone concentrations have been found near Otter Creek and Dolly Sods Wilderness as the pollutants move eastward with the prevailing wind patterns (Environmental Protection Agency, 1973). Ozone concentrations have a diurnal pattern in mountainous areas. Typically, the concentrations will be greater during the day at lower elevations and greater during the night at higher elevations (Berry, 1964). Wolff et al. (1987) have reported that higher elevation sites have a greater average daily ozone concentration and more hours of greater than 80 part per billion of ozone than lower elevations sites.

Ozone enters a host through the stomates of a leaf by either acute or chronic exposures. Acute injury from ozone is expressed as stippling (small, dark, pigmented areas), flecking, bleaching, and bifacial necrosis (Skelly et al., 1987). On hardwood and herbaceous plants the injury is usually confined to the upper leaf surface. However, premature senescence (observed as leaf fall or defoliation) can occur from acute ozone injury. Acute injury occurs to extremely sensitive plants, or plants exposed to a high dose of ozone.

Chronic injury usually occurs to vegetation which is exposed to low doses of ozone for over a period of time. Some broad-leaf plants will exhibit either stippling or flecking when chronic injury has occurred. Premature senescence of the leaves is also another symptom of chronic injury (Lacasse and Treshow, 1978; Treshow, 1970).

Both acute and chronic symptoms can be observed in nature, but ozone can not be analyzed by chemical means to confirm these observations. Ozone oxidizes rapidly and breaks down immediately upon contact with the plant tissue (Lacasse and Treshow, 1978). Therefore, no signs (such as a fungus fruiting body) of ozone are present and the diagnosis is based upon symptoms (such as stippling). Field studies use symptoms to determine those plants expressing injury from ozone, and the apparent damage can not be contributed to ozone with absolute certainty.

Some plants are believed to be useful as bioindicators of the presence or absence of ozone within an area (Bennett and Stolte, 1985). Ozone symptoms have been used in surveys conducted in California (Miller and Millecan, 1971), Maryland, Virginia, Pennsylvania (Davis and Bennett, 1985), and Vermont (O'Brien, 1989). Anderson et al. (1986, 1987, and 1988) have used

bioindicators in surveys conducted in South Carolina, Virginia and the southeastern United States.

PURPOSE

A biological evaluation conducted in 1988 found ozone symptoms present on bioindicators within the Dolly Sods and Otter Creek Wilderness (Jackson and Hay, 1989.). The purpose of this evaluation was to accomplish:

1. Evaluate the current distribution and intensity of apparent ozone damage within the two Wildernesses.

2. Recommend a monitoring strategy, based on survey results, to efficiently monitor ozone impact.

METHODS

The biological evaluation at Otter Creek Wilderness took place August 21 - 23, and August 30, 1989. Site descriptions for the 44 plots established in 1988 are listed in Appendix A. Four plots were not included in 1989 because the plants were removed (cut), the trees were greater than 25 feet in height, or the plot could not be found (see Appendix B). Some of the plants were not examined at 11 of the plots listed in 1988 (Jackson and Hay, 1989) because the plants were defoliated 100 percent (blackberry), a bioindicator was misidentified (for example, fleabane was called common milkweed), there was less than 15 plants in 1989, or a bioindicator was removed during trail maintenance (see Appendix B).

The biological evaluation was conducted at Dolly Sods Wilderness during August 28 - 29, and September 7, 1989. The site description for the 28 plots established in 1988 is listed in Appendix C. One plot could not be found and another was not examined in 1989. Plot number 17 was moved about 330 feet to the north because we could not cross a section of Stone Coal Run. This move resulted in a species change from Viburnum sp. to black cherry (Appendix D).

No stakes or flagging were used to mark the location of the plots in 1988 at Otter Creek or Dolly Sods Wilderness. The plot location were noted on topographic maps (1:24,000) in 1988. Therefore, the approximate location of the plots established in 1988 were found and 15 plants of each ozone bioindicator present were examined and rated:

1) the percentage of foliage with ozone symptoms.

2) the average amount of ozone symptoms, according to the following severity classification:

   0 = absent
   1 = trace (1 to 5 percent of the leaf with symptoms)
   2 = light (6 to 25 percent of the leaf with symptoms)
   3 = moderate (26 to 50 percent of the leaf with symptoms)
   4 = heavy (greater than 50 percent of the leaf with symptoms)

An average intensity rating was calculated for each bioindicator by multiplying the severity category times the percentage of foliage affected (based on the same scale as the severity rating of none to heavy). For example, a plant with 20 percent of its leaves injured with trace symptoms of ozone would be rated 2 (2x1).

RESULTS

Ozone symptoms were present on eight bioindicators (Table 1) at Otter Creek and/or Dolly Sods Wilderness. Currently, the only significant point of this evaluation is that ozone appears to be causing injury to the vegetation at both Wildernesses.

Table 1. A summary of ozone severity for each bioindicator at the Otter Creek and Dolly Sods Wilderness, Monongahela National Forest, 1989*.

Species	Ozone Severity**					Average Percent Foliage Affected	Average Severity
	0	1	2	3	4		
Otter Creek							
Aster	30	0	0	0	0	0.0	0.0
Black cherry	77	10	10	7	1	18.5	0.5
Blackberry	301	9	11	13	11	5.8	0.3
Common milkweed	21	11	8	9	11	22.0***	1.2
Elderberry	92	24	3	1	0	8.9	0.3
Northern fox grape	30	0	0	0	0	0.0	0.0
Tulip poplar	89	1	0	0	0	0.2	0.0
Viburnum sp.	3	6	2	3	1	33.3	1.5
White ash	25	0	2	2	1	10.0	0.4
Witch-hazel	32	7	4	0	2	7.7	0.5
Dolly Sods							
Black cherry	35	5	20	24	21	41.3	1.9
Common milkweed	75	41	43	28	23	29.6***	1.4
Honey locust	15	0	0	0	0	0.0	0.0
Trembling aspen	75	0	0	0	0	0.0	0.0
Viburnum sp.	17	7	22	11	3	47.3	1.6
Witch-hazel	30	0	0	0	0	0.0	0.0

* The results for Otter Creek are from the August 21 - 23, and September 30, 1989 evaluation and August 28 - 30, and September 7, 1989 for the Dolly Sods evaluation.

** 0 = absent; 1 = trace; 2 = light; 3 = moderate; 4 = heavy symptoms

*** This average is low due to premature senescence of the leaves in the lower half of the plants.

Ozone symptoms were present on bioindicators at a majority of the plots (see Figure 1 and 2) at Otter Creek (52 percent) and Dolly Sods (61 percent). At least two more years of data are needed to determine any trends with ozone symptoms at the Wildernesses. However, the 1988 results were probably less severe than the 1989 results because a drought occurred in 1988. Ozone will usually not penetrate into the leaf tissue during drought conditions because the stomates are closed (Lacasse and Treshow, 1978).

The average intensity rating was greater for black cherry and Viburnum sp. at Dolly Sods Wilderness than Otter Creek (Table 2). The large openings at Dolly Sods probably accounts for the increase in ozone symptoms, but there may also be differences in the genotypes of the bioindicators between the two location. Another possible reason for the differences in the intensity ratings is the plots at Dolly Sods are about 500 feet higher in elevation than the plots at Otter Creek Wilderness. Perhaps the plots located in Dolly Sods Wilderness are exposed to greater amounts of ozone than the plots located at lower elevations in Otter Creek Wilderness (Wolff et al., 1987).

Table 2. A summary of ozone intensity ratings for bioindicators at Otter Creek and Dolly Sods Wilderness, Monongahela National Forest, 1989.

Species	Total number observed	Percentage with symptoms	Average Intensity rating
Otter Creek			
Aster	30	0	0.0
Black cherry	105	27	1.9
Blackberry	345	13	1.1
Common milkweed	60	60	5.0
Elderberry	120	23	0.8
Northern fox grape	30	0	0
Tulip poplar	90	1	0.0
Viburnum sp.	15	80	4.6
White ash	30	17	1.8
Witch-hazel	45	29	1.2
Dolly Sods			
Black cherry	105	67	6.8
Common milkweed	210	46	4.6
Honey Locust	15	0	0.0
Trembling aspen	75	0	0.0
Viburnum sp.	60	72	6.0
Witch-hazel	30	0	0.0

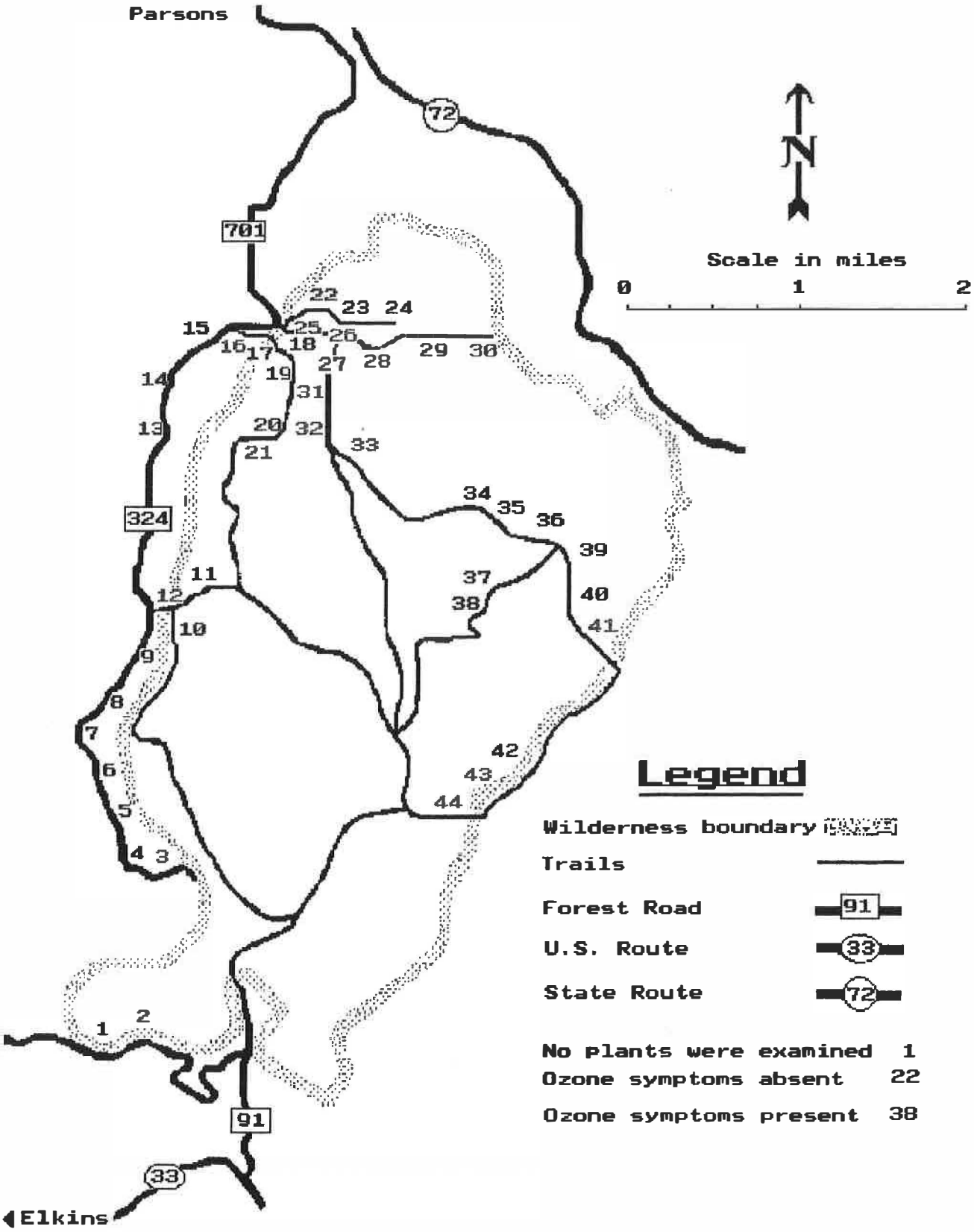

Figure 1. Plot results for Otter Creek Wilderness in 1989.

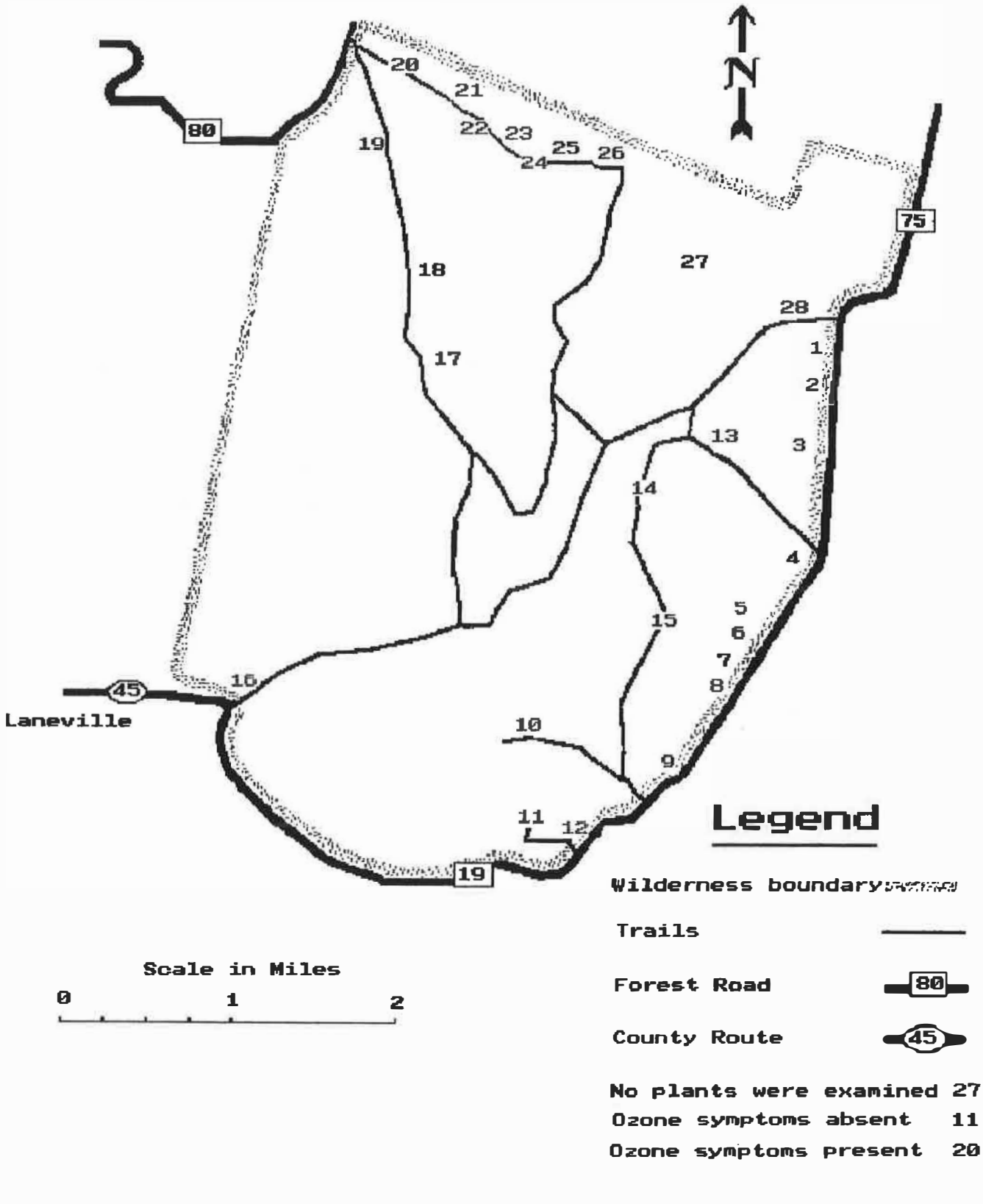

Figure 2. Plot results for Dolly Sods Wilderness in 1989.

DISCUSSION

Otter Creek: Blackberry had ozone symptoms at some of the plots (n=8). We had some difficulty rating some blackberry plants because they were completely defoliated, or the stippling was near the leaf margins. We did not include any plants which had either of these two conditions because we were not confident the conditions were caused by ozone. Perhaps the defoliation and the stippling near the margins were caused by an unidentified fungus. Similar observations were encountered at the Lye Brook Wilderness in 1989 (Dr. Jim O'Brien, Forest Pest Management, personal communication).

Black cherry is widely distributed throughout the Wilderness and 27 percent of the seedling/saplings had ozone symptoms present. Overall, about 18 percent of the foliage had an average severity in the trace category. Combining these two results together gave an average intensity rating of trace ozone symptoms on black cherry. We did observe premature senescence (about 20 percent) with the black cherry on Green Mountain (plots 34 - 38). Many of the overstory trees had premature senescence and ozone appears to have caused the damage because chlorotic leaves with stippling were still attached to the twigs. We also observed the chlorotic leaves with stippling on the forest floor.

Ozone symptoms were seen also on common milkweed, elderberry, and Viburnum sp. The percentage of plants with symptoms ranged between 23 and 80 percent for these three species. Common milkweed is probably the most sensitive bioindicator of all the species at Otter Creek Wilderness. The average severity rating places the common milkweed in the trace category, but the actual rating should be higher. As with black cherry, we could see premature senescence in the lower half of the plants and the leaves on the ground had heavy ozone symptoms. If these defoliated leaves would have been included then common milkweed would have had a moderate severity rating.

Tulip poplar is found commonly in the northern half of the Wilderness, but we saw symptoms present on only one tree. Davis and Bennett (1985) and Anderson et al. (1987) both reported ozone symptoms present on tulip poplar. Our difference is probably related to making less observations and our openings were probably smaller. Also, the symptoms may have have reduced because many of the tulip poplar were infested by tulip poplar weevil (Odontopus calceatus (Say)).

White ash had 17 percent of the plants with symptoms. Perhaps the low incidence of ozone symptoms is due to the genotypes not being susceptible to ozone exposure. Most of the white ash with ozone symptoms were located in a provenance study within the Fernow Experimental Forest. Also, the low incidence of ozone symptoms may be a result of feeding by an insect. Many of the white ash within the Wilderness had a white flecking on the upper leaf surface that appear to be caused by an insect with piercing/sucking mouth parts.

Dolly Sods: Symptoms were seen on black cherry, common milkweed, and Viburnum sp. The frequency of moderate and heavy ozone symptoms increased for these three species (Table 1) in comparison to the 1988 results (Jackson and Hay,

1989), but the average severity of the symptoms remained the same at trace to light. The average percentage of foliage affected with ozone symptoms increased in 1989 for black cherry and Viburnum sp., but the common milkweed average was lower. This lowering resulted from premature senescence of the lower half of the plants. If the defoliated leaves (with heavy symptoms) had been included then the severity rating would have been higher. Overall, the average intensity rating is light for black cherry and Viburnum sp., and the actual intensity rating for common milkweed should probably be moderate.

Premature senescence was evident on the black cherry trees throughout Dolly Sods Wilderness, especially near the Breathed Mountain Trail. Chlorotic leaves with stippling were seen on the ground and attached to twigs as was seen on Green Mountain at Otter Creek Wilderness.

RECOMMENDATIONS

Resource data is needed by the Monongahela National Forest to determine if new major pollution emission sources will violate the Clean Air Act of 1977. Therefore, the following steps would strengthen and support the decisions made by resource managers in evaluating the potential impact of new pollution sources.

1. This biological evaluation should be repeated annually to determine if ozone symptoms vary over time.

2. Ozone fumigation studies should be conducted using several species from each Wilderness. Seeds (or cuttings) should be collected for black cherry, common milkweed, and tulip poplar from Otter Creek Wilderness; and for black cherry, common milkweed, and Viburnum sp. from Dolly Sods Wilderness. A wide variety of genotypes from each species should be collected, gathering plants with and without ozone symptoms. Seedlings can then be fumigated at various levels of ozone to quantify the ozone damage. Furthermore, these seedlings should be planted in large openings within the two Wildernesses to give a rough estimate of the ozone levels in a particular year.

3. The most reliable data would be obtained by monitoring actual ozone levels near the two Wildernesses. This approach would require using chambers to cover seedling (tested in item number 2) to remove the ambient ozone. Seedlings exposed to ambient ozone levels (controls) are also needed. Ideally, the tests should be done within the Wildernesses, but this is not practical. Perhaps this step could be implemented at Canaan Valley State Park because this location is between the Wildernesses and is located at a high elevation.

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LITERATURE CITED

Anderson, Robert L., Colleen Scarrow, and John Knighten. 1986. Survey for ozone-caused injury on sensitive plant species on the Francis Marion National Forest and Bull Island (Cape Romain National Wildlife Refuge). Report 87-1-3. USDA Forest Service, Forest Pest Management, Asheville, NC. 11p.

Anderson, Robert L., John Knighten, Thomas C. McCartney, and Collen Scarrow. 1987. Survey of the James River Face Wilderness Area on the Jefferson National Forest, Virginia, for air pollution-caused symptoms on vegetative bioindicator plants. USDA Forest Service, Forest Pest Management, Asheville, NC. 7 p.

Anderson, Robert L., H. Daniel Brown, Boris I. Chevone, and Thomas C. McCartney. 1988. Occurrence of air pollution symptoms (needle tip necrosis and chlorotic mottling) on eastern white pine in the southern Applachian Mountains. Plant Disease 72:130-132.

Bennett, James P. and Kenneth W. Stolte. 1985. Using vegetation biomonitors to assess air pollution injury in National Parks - Milkweed survey. 1985. National Park Service Natural Resources Report Series No. 85-1. USDI National Park Service, Denver, CO. 16 p.

Berry, Charles R. 1964. Differences in concentrations of surface oxidant between valley and mountaintop conditions in the Southern Appalachians. Journal of the Air Pollution Control Association 14(6): 238-239.

Davis, Donald D. and James P. Bennett. 1985. Evaluation of air pollution injury to vegetation in four Mid-Atlantic National Park Services Areas. CAES No. 756-85. The Pennsylvania State University, Center for Air Environment Studies, University Park, PA. 72p.

Environmental Protection Agency. 1973. Investigation of high ozone concentration in the vicinity of Garrett County, Maryland and Preston County, West Virginia. EPA-R4-73-019. Office of Research and Monitoring, U.S.Environmental Protection Agency, Washington, D.C. 106 p.

Jackson, William and Hay, Janan. 1989. Ozone symptoms were present on bioindicator plants at the Otter Creek Wilderness and Dolly Sods Wilderness, Monongahela National Forest. USDA Forest Service, Forest Pest Management, Morgantown, WV. 13 p.

Lacasse, N. L., and M. Treshow (eds.). 1978. Diagnosing vegetation injury caused by air pollution. EPA-450/3-78-005. Developed by Applied Science Associates for U.S. Environmental Protection Agency. 217 pp.

Miller, Paul Robert and Arthur A. Millecan. 1971. Extent of oxidant air pollution damage to some pines and other conifers in California. Plant Disease Reporter 55(6):555-559.

O'Brien, James T. 1989. Evaluation of ozone damage to vegetation on the Lye Brook Wilderness in 1988. USDA Forest Service, Forest Pest Management, Durham, NH. 12 p.

Skelly, John M., Donald D. Davis, William Merrill, E. Alan Cameron, H. Daniel Brown, David B. Drummond, and Leon S. Dochinger (eds.). 1987. Diagnosing Injury to Eastern forest trees. USDA Forest Service, Forest Pest Management and The Pennsylvania State University. 122 p.

Treshow, Michael. 1970. Ozone damage to plants. Environmental Pollution. 1:155-161.

Wolff, George T., Paul J. Lioy, and Richard S. Taylor. 1987. The diurnal variations of ozone at different altitudes on a rural mountain in the Eastern United States. Journal of the Air Pollution Control Association 37(1): 45-48.

APPENDICES

Appendix A. Site characteristics of the 44 ozone plots at the Otter Creek Wilderness, Monongahela National Forest, July 18 - 22, 1988.

Plot Number	Azimuth	Elevation (feet)	Slope Position	Percent Slope	Site Description	Site Disturbances
1	98	3660	middle	15	trail opening	old logging road
2	18	3620	upper	40	along the road	
3	144	3160	middle	35	along the road	
4	212	3220	middle	45	along the road	
5	265	3320	middle	35	along the road	
6	263	3480	middle	30	along the road	
7	250	3560	upper	55	along the road	
8	280	3500	middle	60	along the road	
9	344	3400	middle	60	along the road	
10	325	3380	middle	10	trail opening	old logging road
11	---	3300	flat	0	forest opening	old beaver meadow
12	84	3300	middle	10	along the road	
13	300	2800	middle	5	clear cut / planted	logging evidence
14	---	2780	flat	0	clear cut	logging evidence
15	338	2640	lower	30	clear cut	logging evidence
16	160	2640	middle	30	trail opening	old logging road
17	170	2640	middle	15	trail opening	old logging road
18	206	2650	middle	60	trail opening	old logging road
19	190	2780	middle	30	trail opening	old logging road
20	178	2940	middle	40	trail opening	old logging road
21	190	3020	middle	30	trail opening	old logging road
22	94	2480	middle	30	trail opening	old logging road
23	162	2460	middle	10	trail opening	old logging road
24	192	2550	middle	75	trail opening	old logging road
25	156	2150	lower	15	trail opening	
26	110	2200	middle	10	trail opening	
27	84	2140	lower	30	forest opening	
28	---	2060	flat	0	trail opening	
29	---	2060	flat	0	trail opening	
30	---	1920	flat	0	trail opening	
31	---	2100	flat	0	forest opening	
32	---	2100	flat	0	forest opening	
33	---	2260	flat	0	forest opening	old logging camp
34	---	3320	flat	0	trail opening	
35	---	3340	flat	0	trail opening	
36	170	3340	flat	5	trail opening	
37	330	3380	upper	5	trail opening	
38	---	3365	flat	0	trail opening	
39	---	3540	flat	0	trail opening	
40	60	3540	upper	35	trail opening	
41	40	3560	upper	35	trail opening	
42	---	3500	ridge top	0	trail opening	
43	200	3460	ridge top	3	trail opening	
44	172	3320	upper	65	trail opening	

Appendix B. Average percentage of foliage affected by ozone symptoms, and the average severity of the ozone symptoms at Otter Creek Wilderness, Monongahela National Forest, August 21 - 23 and September 30, 1989.

Plot Number	Blackberry		Black Cherry		Common Milkweed*/		Elderberry		Tulip poplar		White Ash	
	Percent Affected	Average Severity	Percent Affected	Average Severity	Percent Affected	Average Severity	Percent Affected	Average Severity	Percent Affected	Average Severity	Percent Affected	Average Severity
1					PLANTS REMOVED							
2	0	0.0										
3	DEFOLIATED								0	0.0		
4	10	0.3										
5	19	0.9							0	0.0		
6	DEFOLIATED		5	0.2								
7	0	0.0					2	0.1				
8	19	1.2	PIN CHERRY		FLEABANE							
9	29	1.5			FLEABANE							
10	DEFOLIATED		9	0.6								
11												
12									0	0.0		
13	9	0.7			13	0.5			1	0.1	25	0.9
					46	2.8						
14	0	0.0			41	3.0						
15	0	0.0					8	0.4	NOT FOUND			
16	0	0.0			NOT FOUND							
17	0	0.0			7	0.3						
18	0	0.0					18	0.6				
19							35	0.6				
20	17	1.3							0	0.0	0	0.0
21	PLANTS REMOVED								0	0.0		
22	0	0.0										
23	LESS THAN 15 PLANTS											
24							8	0.5	LESS THAN 15 PLANTS			
25							0	0.0				
26							0	0.0				
27	1	0.1										
28	0	0.0										
29	0	0.0										
30	0	0.0										
31	0	0.0					0	0.0				
32	0	0.0										
33	0	0.0										

*/ At plot 13 there were two clones of common milkweed evaluated

Appendix B. Continued

Plot Number	Blackberry Percent Affected	Blackberry Average Severity	Black Cherry Percent Affected	Black Cherry Average Severity	Common Milkweed Percent Affected	Common Milkweed Average Severity	Elderberry Percent Affected	Elderberry Average Severity	Tulip poplar Percent Affected	Tulip poplar Average Severity	White Ash Percent Affected	White Ash Average Severity
34			2	0.1								
35			79	1.6								
36			TREES TOO TALL									
37			18	0.4								
38			17	0.7								
39												
40	COULD NOT FIND PLOT		COULD NOT FIND PLOT									
41	COULD NOT FIND PLOT		COULD NOT FIND PLOT									
42	25	1.6										
43			0	0.0								
44	0	0.0										
Average	5.8	0.3	18.5	0.5	22.0	1.2	8.9	0.3	0.2	0.0	10.0	0.4

Appendix B. Continued.

Plot Number	Aster		Northern Fox Grape		Witch-hazel		Viburnum sp.	
	Percent Affected	Average Severity	Percent Affected	Average Severity	Percent Affected	Average Severity	Percent Affected	Average Severity
11					8	0.9	33.3	1.5
23	0	0.0	0	0.0				
24	0	0.0	0	0.0				
39					15	0.6		
41					0	0.0		
Average	0	0.0	0	0.0	7.7	0.5	33.3	1.5

Appendix C. Site characteristics of the 28 ozone plots at the Dolly Sods Wilderness, Monongahela National Forest, August 22 - 25, 1988.

Plot Number	Azimuth	Elevation (feet)	Slope Position	Percent Slope	Site Description	Site Disturbances
1	280	4020	upper	5	along the road	
2	273	4030	upper	20	along the road	
3	273	4000	upper	5	along the road	
4	---	4010	ridge top	0	along the road	logging evidence
5	10	3960	upper	5	open field	logging evidence
6	---	3960	flat	0	forest opening	logging evidence
7	---	3960	flat	0	open field	logging evidence
8	---	3940	ridge top	0	along the road	logging evidence
9	140	4000	ridge top	5	along the road	
10	353	3880	upper	5	trail opening	old logging road
11	235	4000	upper	20	wildlife opening	
12	244	3940	middle	15	trail opening	old logging road
13	300	3610	ridge top	5	wildlife opening	
14	300	3640	ridge top	2	wildlife opening	
15	290	3780	ridge top	5	forest opening	
16	---	2740	flat	0	trail opening	old logging road
17	309	3700	middle	10	sod	
18	228	3720	upper	10	sod	
19	---	3720	flat	0	sod	
20	203	3800	upper	10	sod	
21	342	3800	lower	5	sod	beaver pond
22	311	3810	upper	5	sod	beaver pond
23	290	3840	upper	5	wildlife opening	
24	110	3820	upper	5	sod	
25	---	3820	flat	0	sod	
26	---	3800	flat	0	sod	
27	---	3830	flat	0	forest opening	
28	222	3820	upper	10	forest opening	

Appendix D. Average percentage of foliage affected by ozone symptoms, and the average severity of the ozone symptoms at Dolly Sods Wilderness, Monongahela National Forest. August 28 - 30 and September 7, 1989.

Plot Number	Black Cherry		Common Milkweed*/		Honey Locust		Trembling Aspen		Viburnum sp.		Witch-hazel	
	Percent Affected	Average Severity	Percent Affected	Average Severity	Percent Affected	Average Severity	Percent Affected	Average Severity	Percent Affected	Average Severity	Percent Affected	Average Severity
1			13	1.0								
2			19	0.8								
3			11	1.1								
4			61	3.3								
5											0	0.0
6											COULD NOT FIND PLOT	
7									1.3	0.1		
8							0	0.0				
9			7	0.9								
10	0	0.0										
11					0	0.0						
12											0	0.0
13			50	0.9								
			20	0.5								
			0	0.0								
			37	2.2								
14			47	2.6								
			15	0.7								
			69	3.1								
15	43	2.3	65	3.1								
16			0	0.0								
17	64	2.5							PLOT WAS MOVED			
18							0	0.0	47	1.4		
19	65	2.7										
20									82	2.7		
21	37	2.0					0	0.0				
22	23	0.9										
23							0	0.0				
24							0	0.0				
25									58.7	2.3		
26	57	2.9										
27									COULD NOT FIND PLOT			
28	PLOT WASN'T EXAMINED											
Average	41.3	1.9	29.6	1.4	0.0	0.0	0.0	0.0	47.3	1.6	0.0	0.0

*/ At plot 13 there were four clones of common milkweed evaluated, and at plot 14 there were three clones of common milkweed evaluated.